

REMARKS

In view of the above amendments and the following remarks, reconsideration of the outstanding office action is respectfully requested. Pursuant to 37 CFR § 1.121, attached as Appendix A is a Version With Markings to Show Changes Made.

Integrated circuit chips are steadily becoming smaller and more powerful. The current trend is to produce integrated chips which are steadily increasing in density and perform many more functions in a given period of time over predecessor chips. This results in an increase in the electrical current used by these integrated circuit chips. As a result, these integrated circuit chips generate more ohmic heat than the predecessor chips. Accordingly, heat management has become a primary concern in the development of electronic devices.

Typically, heat generating sources or devices, such as, integrated circuit chips, are mated with heat sinks to remove heat which is generated during their operation. However, thermal contact resistance between the source or device and the heat sink limits the effective heat removing capability of the heat sink. During assembly, it is common to apply a layer of thermally conductive grease, typically a silicone grease, or a layer of a thermally conductive organic wax to aid in creating a low thermal resistance path between the opposed mating surfaces of the heat source and the heat sink. Other thermally conductive materials are based upon the use of a binder, preferably a resin binder, such as, a silicone, a thermoplastic rubber, a urethane, an acrylic, or an epoxy, into which one or more thermally conductive fillers are distributed.

Typically, these fillers are one of two major types: thermally conductive, electrically insulative or thermally conductive, electrically conductive fillers. Aluminum oxide, magnesium oxide, zinc oxide, aluminum nitride, and boron nitride are the most often cited types of thermally conductive, electrically insulative fillers used in thermal products. Boron nitride is especially useful in that it has excellent heat transfer characteristics and is relatively inexpensive.

However, in order to achieve sufficient thermal conductivity with presently used fillers, such as boron nitride, it has been necessary to employ high loadings of filler in the binder (see, e.g., U.S. Patent No. 5,898,009 to Shaffer et al. and U.S. Patent No. 6,048,511 to Shaffer et al.). Thus, there is a need for thermally conductive filler materials which can be used at low loading levels to achieve sufficient thermal conductivity. The present invention is directed to overcoming this deficiency in the art.

Applicants hereby affirm the election of Group II (claims 13-16), drawn to a boron nitride powder, with traverse. However, applicants submit that all groups of invention identified in the outstanding office action and new claims 17-22 are closely related and, therefore, would require common areas of search and consideration. Accordingly, no benefit is derived from maintaining the restriction requirement and withdrawal of the restriction requirement is respectfully requested. In view of the foregoing, applicants submit that the claims of Groups I and II should be examined on the merits at this time. Moreover, applicants submit that, at a minimum, new claims 17-22 should be examined with the claims of Group II. Support for new claims 17-22 is found, for example, at page 7, lines 10-25 of the specification.

The rejection of claims 13-16 under 35 U.S.C. § 102(a, b, or e) as anticipated by, or in the alternative, as obvious over U.S. Patent No. 5,898,009 to Shaffer et al. ("Shaffer I"), U.S. Patent No. 6,048,511 to Shaffer et al. ("Shaffer II"), U.S. Patent No. 5,985,228 to Corrigan et al. ("Corrigan"), or U.S. Patent No. 5,854,155 to Kawasaki et al. ("Kawasaki") is respectfully traversed. Support for the amendments to claim 13 is found, for example, at page 3, lines 3-9 and page 4, lines 6-12 of the specification.

Shaffer I and II relate to a method of forming pellets or agglomerates of high density boron nitride (BN) by crushing high purity hexagonal boron nitride (hBN) into BN particles extending over a size range of at least 100 μm with a majority of the particles having a particle size above 50 μm and cold pressing the crushed particles into a compacted form. The compacted form is then granulated and again cold pressed to form pellets or agglomerates of BN particles, which can then be crushed into a powder.

Corrigan relates to a method for converting hBN particulates into cubic BN (cBN) particles or agglomerates. This reference discloses that the hBN source powder is densified or pre-pressed into an agglomerated mass or billet at low temperatures, and the mass or billet is then granulated into agglomerated particles of a desired size. Corrigan also discloses that the hBN particles may be vacuum heated and fired, prior to compression and granulation, to remove volatile impurities.

Kawasaki relates to melamine borate particles, hBN particles and an hBN powder produced using the melamine borate particles, a resin or rubber composite containing the hBN powder, an hBN sintered body, and methods of making the above products. This reference discloses formation of an hBN powder by mixing melamine borate particles, or a mixture containing them, and a crystallization catalyst and firing the mixture in a non-

oxidizing gas atmosphere at from 1700 °C to 2200 °C. Kawasaki also discloses a method for producing hBN powder by calcining melamine borate particles, or a mixture containing them, to form amorphous BN or hBN, adding a crystallization catalyst, and firing the resulting mixture. This reference further distinguishes the hBN particles obtained in accordance with the invention of Kawasaki from conventional hBN particles, such as non-aggregated scaly particles, hBN blocks wherein crystals are undeveloped, granulated particles, or particles obtained by pulverizing an hBN sintered body.

It is the position of the U.S. Patent and Trademark Office ("PTO") that Shaffer I, Shaffer II, Corrigan, and Kawasaki each teach boron nitride powders including agglomerates. Thus, the PTO states that the burden is on the applicant to prove by way of tangible evidence that the prior art compositions do not necessarily possess characteristics attributed to the claimed composition.

As set forth in the specification of the present application at Example 1 (page 8, lines 5-18), the powders disclosed in Shaffer I, Shaffer II, Corrigan, and Kawasaki, do not necessarily have a thermal diffusivity of 0.15 cm²/s to about 0.20 cm²/s, as required by the claims of the present application. In particular, as set forth in Example 1, boron nitride powder having a surface area of 2 to 4 m²/g, an average agglomerate size less than 210 microns, a primary platelet size of 6 to 12 microns, an oxygen content of less than 1%, and a B₂O₃ content of less than 0.1%, was isopressed at 20 ksi into a compacted form (all experiments were repeated twice). The compacted form of boron nitride had a green density of between 1.66 and 1.70 g/cc. The thermal diffusivity was measured by laser flash technique (using an Appollo Laser, Model M22) and was found to be between 0.085 and 0.14 cm²/sec. The compacted green bodies were then sintered at 2000 °C for 0.5 to 2 hours. The density of the sintered body was found to have decreased to 1.42 to 1.55 g/cc. The thermal diffusivity was measured again by the same technique and found to have increased to 0.182 cm²/sec. Thus, by sintering the compacted form of boron nitride, the thermal diffusivity was raised to between about 0.15 cm²/s and about 0.20 cm²/s, as required by the claims of the present invention. More specifically, as set forth at page 5, lines 20-27 of the specification, the sintering step improves the thermal diffusivity and, thus, thermal conductivity of the resulting boron nitride powder. Although not wishing to be bound by theory, it is believed that during sintering, individual grains of boron nitride grow into each other to form an interconnected network. The interconnectivity of the resulting sintered body results in increased thermal diffusivity and increased thermal conductivity.

None of Shaffer I, Shaffer II, Corrigan, or Kawasaki disclose or suggest pressing hBN to produce a compacted form, sintering the compacted form, and then crushing to produce a powder. In particular, in Shaffer I and II, to produce the disclosed powders, hBN is crushed into particles with a size range of at least 100 μm , the crushed particles are cold pressed, granulated, cold pressed again to form pellets, and then crushed into a powder. As described above and in Example 1 of the specification of the present application, pressing and crushing an hBN powder, as disclosed in Shaffer I and II, will not necessarily produce a powder having a thermal diffusivity between 0.15 cm^2/s and about 0.20 cm^2/s . In contrast, in Example 1 of the present application, when pressing without sintering, a thermal diffusivity of from 0.085 cm^2/s to 0.14 cm^2/s is obtained.

Similarly, Corrigan, which discloses pressing hBN powder into an agglomerated mass or billet at low temperatures, and then granulating the mass or billet (with optional pre-treatment to remove impurities) into agglomerated particles of a desired size, does not disclose sintering of a compacted form of hBN to produce an hBN powder. As described above, pressing and crushing (or granulating) an hBN powder will not necessarily produce a powder having a thermal diffusivity between 0.15 cm^2/s to about 0.20 cm^2/s . In contrast, in Example 1 of the present application, when pressing without sintering, a thermal diffusivity of from 0.085 cm^2/s to 0.14 cm^2/s is obtained.

Further, Kawasaki discloses mixing melamine borate particles, or a mixture containing them, and a crystallization catalyst and firing the mixture in a non-oxidizing gas atmosphere at from 1700 $^{\circ}\text{C}$ to 2200 $^{\circ}\text{C}$. Kawasaki also discloses a method for producing hBN powder by calcining melamine borate particles, or a mixture containing them, to form amorphous BN or hBN, adding a crystallization catalyst, and firing the resulting mixture. Further, Kawasaki discloses formation of a sintered body using the resulting hBN powder. Thus, Kawasaki relates to formation of a starting hBN powder and its use to produce a sintered body, but does not disclose sintering of a compacted form of hBN with subsequent crushing to produce an hBN powder. As described above, without sintering a compacted form of hBN, an hBN powder having a thermal diffusivity between 0.15 cm^2/s to about 0.20 cm^2/s will not necessarily be obtained.


Accordingly, none of Shaffer I, Shaffer II, Corrigan, or Kawasaki disclose or suggest an hBN powder having a thermal diffusivity between 0.15 cm^2/s to about 0.20 cm^2/s , as required by the claims of the present application. In addition, as described above, none of Shaffer I, Shaffer II, Corrigan, or Kawasaki necessarily disclose an hBN powder having a

thermal diffusivity between $0.15 \text{ cm}^2/\text{s}$ to about $0.20 \text{ cm}^2/\text{s}$, as required by the claims of the present application. Therefore, this rejection is improper and should be withdrawn.

In view of all of the foregoing, applicant submits that this case is in condition for allowance and such allowance is earnestly solicited.

Respectfully submitted,

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Georgia Evans
Registration No. 44,597

NIXON PEABODY LLP
Clinton Square, P.O. Box 31051
Rochester, New York 14603-1051
Telephone: (585) 263-1672
Facsimile: (585) 263-1600

Appendix A

Version With Markings to Show Changes Made

In reference to the amendments made herein to claim 13, additions appear as underlined text, while deletions appear as bracketed text, as indicated below:

In The Claims:

13. (Amended) A boron nitride powder having a thermal diffusivity of from about [0.14] 0.15 cm²/s to about 0.20 cm²/s and an average particle size of from about 2 μm to about 20 μm.